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ABSTRACT

An experiment in an introductory psychology course investigated whether gains in final exam performance, similar to those reported in the personalized system of instruction (PSI) literature, could be obtained by substituting a computer for human proctors. The course was divided into two sections, with a sample of 17 students in section 1 matched in precourse knowledge with 17 students in section 2. Student subjects in both sections used an introductory psychology text accompanied by a behavioral objectives study guide. Students in section 1 took quizzes at computer terminals, while section 2 students took manual quizzes. Although students in section 1 were allowed to work at their own pace, they had to have no less than eight of the ten questions correct on each unit quiz before proceeding to the next unit; students in section 2 had to proceed to the next unit regardless of the score obtained on a given quiz. All subjects received immediate feedback on the quizzes. Students using the computer performed significantly better than those in the other section on the final exam. On an attitude questionnaire given to all student subjects, students in the computer managed instruction (CMI) section, felt they had attained a better understanding of basic concepts and principles and gave their section an overall higher rating than the traditional group. CMI students also found the process of taking quizzes at a computer terminal "pleasant." (CMV)

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COMPUTER-MANAGED INSTRUCTION PRODUCES BETTER LEARNING IN AN INTRODUCTORY PSYCHOLOGY COURSE

BY

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and
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Computer-Managed Instruction Produces Better Learning in an Introductory Psychology Course

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Introduction

After a 1972 survey revealed that approximately 35 percent of the introductory psychology students at Harper College received failing or near failing grades on their final examinations, the authors began searching for a more effective teaching technique. A review of the literature uncovered a technique known as the Keller Plan or Personalized System of Instruction (PSI), which seemed to offer a possible solution to the problem.

The Keller Plan employs a form of "mastery learning" in which the student works at his own pace through a series of study units. He is required, however, to demonstrate "mastery" of a particular unit by obtaining a score of 80 to 90 percent on a unit quiz before proceeding to the next one (for a more detailed description of the actual procedures see Kulik, Kulik, and Carmichael, 1974, p. 379).

A seemingly essential element for the implementation of the Keller Plan is the student proctor. Proctors are responsible for assisting students in their studies, administering unit quizzes, grading quizzes, and discussing the results with the student. In addition, the proctor must keep progress files on each student. Because the responsibilities are numerous and time consuming, a proctor typically works with a maximum of eight to ten students. Without proctors it would seem to be extremely difficult to implement a course which incorporates mastery and self-pacing.

Unfortunately, at a community college such as Harper, rapid student turnover makes it difficult to find, train, and adequately supervise proctors. Further, restrictions on special course offerings and a lack of funds make it almost impossible to find a means of adequately compensating proctors.

Harper's acquisition of a computer for instructional purposes seemed to offer a solution to this problem. By having the computer perform many of the clerical functions of a student proctor (i.e. testing, grading, and record keeping), it seemed possible to retain the mastery and self-pacing features of the Keller plan without the use of proctors. Although the authors recognized that the elimination of human proctors might result in the loss of a certain amount of the personal attention and assistance which students typically receive, it was not clear whether such a loss would be detrimental.

The first step in the process of implementing a computer managed course was the acquisition of appropriate software. A review of several CMI programs such as the interactive version of TIPS developed by R. R. Roskos at the University of Wisconsin, LaCrosse, indicated that none of the then available software would completely satisfy the needs of the proposed course. Therefore, the authors decided to develop their own software. At the time the present study was conducted, the software consisted of the following nine programs:[1]

PSYTST: Allows the student to access the system, reads the student's record to determine which quiz he should take, and chains to the appropriate quzzing program.

PQ1-PQ10: (The actual quizzing program.)[2] The program makes up a quiz (by randomly selecting questions from the appropriate QUIZ file of forty-eight test items), administers the quiz to the student,

scores it, provides the student with feedback (from the appropriate FDBK file) regarding concepts he does not understand, and gives him page references to portions of the text. The program also writes test item analysis data into the appropriate ANSW file. PQ chains to SCRIPT. (See sample output in Appendix.)

SCRIPT: Writes the student's score in his individual progress record contained in the RSLTS file. SCRIPT chains to DUMMY.

DUMMY: This program dumps the student out of the CMI system and thereby prevents him from tampering with any of the major system programs.

SKLKEY: A file management program which allows an unsophisticated user to load test and feedback items into appropriate files, as well as modify items, and make lists of the contents of the files.

LOAD: Allows the instructor to input class lists into a newly established RSLTS file.

DATUM: Allows the instructor to add, delete, or modify individual scores in a student's record, as well as erase an entire student record.

RSLTS: Provides the instructor with an updated printout from the RSLTS file. This includes a listing of each student in the class, displays the scores of all quizzes taken by the student, and the date upon which each unit was completed. If desired, a bonus point for each unit passed before its particular due date can be awarded automatically. This encourages the student to keep up with his work. As soon as the student has finished the course, RSLTS automatically totals the highest obtained score on each of the units. RSLTS also provides useful information such as (1) the mean and standard deviation of score totals, and (2) the mean and standard deviation of the number of trials required by the class to attain mastery on each unit, which is useful for evaluating difficulty levels. (See sample output in Appendix.)

ANLSIS: Provides the instructor with a detailed test item analysis for questions in the QUIZ file. For multiple choice and true-false items, it prints the number and percentage of students who selected each alternative response. For fill-in questions, it prints the number and percentage of students who answered the question correctly and makes a print-out of all answers which the computer accepted as "correct" and all responses which the computer rejected. This information helps the instructor determine how to adjust the "key lettering" of fill-in answers so that he can allow for acceptable misspellings.

In light of the first year of experience with the CMI software, one additional program (RESPON) has been added. Upon completing each unit quiz at a CRT, the student immediately executes RESPON from a nearby printer, thereby producing a hard copy of appropriate feedback information.

In addition, RESPON prints out a table with the following information: the record number of the item, the student's response to it, whether the response was correct or incorrect, and the student's reaction time in seconds. (See sample output in Appendix.) Prior to the development of RESPON students had to read their feedback messages from the CRT and write them down on paper. With RESPON both the students and the instructor save considerable time and effort. The information provided by RESPON is also valuable for resolving student disputes about the grading of quizzes as well as counseling students regarding their conceptual weaknesses.

Purpose

The purpose of the study was to answer the empirical question of whether gains in final exam performance similar to those reported in the PSI literature could be attained by the use of a computer instead of human proctors. An additional purpose was to discover whether student attitudes towards a computer managed course would be at least as favorable as those towards a traditional lecture-discussion class.

Subjects

Student signed up for one of two sections of introductory psychology without prior knowledge that different teaching techniques would be used in each section. These groups

were designated "CMI" and "Traditional" to correspond to the teaching methods used. Originally the CMI group consisted of 27 students and the Traditional group consisted of 22 students. In order to assure that the precourse knowledge of the subject matter was the same in the two groups, the subjects were matched on the basis of a 100 question, multiple-choice comprehensive examination. As a result, the final sample consisted of 17 matched-pairs of subjects.

Procedure

Students in the CMI group used as their text *Psychology: Explorations in Behavior and Experience* by Mednick, Higgins, and Kirschenbaum, and the accompanying behavioral objectives study guide by Pasen and Roll. In addition, each week CMI students attended 40 minutes of lecture-demonstration and spent 110 minutes studying, receiving individual help from the instructor, or taking quizzes at the computer terminals. The computer administered 10-question, randomly generated quizzes to each student. It also provided immediate feedback to the student regarding his score, listed all concepts that were not adequately understood, and referred the student to appropriate pages in the text for further study. Although students in this group were allowed to work at their own pace, each unit had to be "mastered" (i.e., no less than eight correct) before the student could proceed to the next unit.

Students in the Traditional group used the same text as the CMI group, but did not use the objectives study guide. In addition to attending 150 minutes of lecture each week, students in this group took a single 10-question manual quiz which consisted of items selected at random from the same question files used with the CMI group.

The Traditional group also received immediate feedback on its quizzes and could discuss problem areas with the instructor, but could not retake quizzes. Students in this group had to proceed to the next unit regardless of the score obtained on a given quiz.

At the end of the semester, students in both groups were given the same 100-question final exam, which earlier had been used as a pre-test for matching purposes. This exam consisted of ten multiple-choice questions for each of the ten units covered during the semester. None of the items used for quizzing purposes for either group appeared on the exam. The Kuder-Richardson estimate of the reliability for the exam was .91 (KR-20).

At the completion of the term, the students in the two groups also filled out a forty item attitude questionnnaire consisting of five-point rating scales assessing various dimensions of the class experience.

Results

Pretest: The mean pretest score for the CMI group was 40.12 (n=17, S.D. =5.28). The mean pretest score for the Traditional lecture discussion group was 40.12 (n=17, S.D.=5.16). A t-test for matched groups indicated that there was no significant difference in the pre-course knowledge of psychology between the two groups (t=0, d.f.=16).

Final Exam: The mean final exam performance for the CMI group was 73.35 (n17, S=15.72), while that of the Traditional lecture-discussion group was 56.94 (n=17, S=11.22). A t-test for matched groups indicated that the difference of 16.41 points was highly significant (t=63, d.f.=16, $p<.001$).

Questionnaire: Because the questionnaires were filled out anonymously, it was not possible to isolate the responses for the seventeen matched pairs of subjects. Nevertheless, the resulting comparison of all twenty-seven subjects in the CMI group and twenty-two subjects in the Traditional group offers some interesting insights into student reactions to the use of computers in the classroom. For the sake of brevity, only six of the more relevant items are discussed in the present article.[3] The items as they appeared on the questionnaire are listed below:

1. In comparison with other courses I have taken, I feel that my *understanding* of basic concepts and principles in this course is
   a. much greater
   b. greater
   c. about the same
   d. less
   e. much less

2. Considering all of the qualities which are applicable, how would you rate this course?

A	B	C	D	E
Excellent		Average		Very Bad

3. In helping you to learn the course content, how would you rate the contribution of the *instructor*?

A	B	C	D	E
Very Helpful		Neutral		Very Unhelpful

4. In comparison with other courses I have taken, the amount of individual help I am able to get from my instructor in this class is
   a. much greater
   b. greater
   c. about the same
   d. less
   e. much less

5. In helping you to learn the course content how would you rate the computer quizzing system?

A	B	C	D	E
Very Helpful		Neutral		Very Unhelpful

6. The idea of taking my chapter quizzes at a computer terminal is

A	B	C	D	E
Very Pleasant		Neutral		Very Unpleasant

A summary of the students' responses to these items appears in Table 1.

As can be seen in Table 1, students in the CMI group felt they attained a better understanding of basic concepts and principles and gave the course a higher over-all rating. Although there was no difference between the groups in the extent to which they perceived the instructor as helping them master the course content, the students in the CMI group felt significantly more *able* to get individual help from the instructor. If the assumption is made that a rating of 3 on item #5 really constitutes a "neutral" rating, then the mean rating of 4.04 by the students in the CMI group means they perceived the computer quizzing system as "helpful." If a similar assumption is made about a rating of 3 on item #6, then the mean rating of 4.26 by the students in the CMI group means that they found the process of taking quizzes at a computer terminal "pleasant."

Table 1. Attitude Ratings of the CMI and Traditionally Taught Groups

Item	*Group*	*No.*	*Mean*	*S.D.*	*t-Value*	*Significance Level**
1. Understanding of basic concepts	CMI	27	3.50	.67	t=3.04	p<.01
	TRAD	22	3.50	1.14	d.f.=47	
2. Over-all course rating	CMI	27	4.52	.85	t=3.35	p<.01
	TRAD	22	3.68	.89	d.f.=47	
3. Contribution of instructor to learning	CMI	27	3.93	.87	t=.10	p>.05
	TRAD	22	3.95	1.09	d.f.=47	
4. Amount of individual help from instructor	CMI	27	3.81	1.00	t=3.52	p<.001
	TRAD	22	2.77	1.06	d.f.=47	
5. Helpfulness of computer quiz system	CMI	27	4.04	1.09		
6. Pleasantness of taking quizzes from computer	CMI	27	4.26	1.13		

*all t-tests are 2-tailed

Discussion

As previously mentioned, the CMI group obtained a significantly higher mean final exam score than the Traditional group. This finding is confounded, however, by the fact that different teachers taught the two groups. The fact that students in the CMI group did not perceive that they learned any more from their instructor than did the students in the Traditional group (see item #3 of Table 1) suggests that differential teacher effectiveness was not the critical factor in determining the difference between the two groups in final exam performance. It seems more likely that the superior performance of the CMI group was due to the greater effectiveness of the CMI strategy.

The responses to item #1 of the attitude questionnaire (see Table 1) indicate that members of the CMI group felt that they gained a greater understanding of basic concepts and principles than did the members of the Traditional group. Thus, the students in the CMI group not only learned more as indicated by the final exam results, but they also had a greater feeling of achievement.

An often heard criticism regarding the use of computers in education is that they depersonalize the learning process because the student is forced to interact almost exclusively with a machine and has little access to a human instructor. In the present study, however, the responses to item #4 of the questionnaire (see Table 1) suggest that students in the CMI group were able to get more individual attention from the instructor than students in the Traditional group. This is most likely due to the fact that the use of a computer to perform routine clerical duties such as quizzing, grading, and record keeping allows the instructor to spend more time in assisting students on an individual basis.

The responses of the CMI group to two of the questions suggest that the computer quizzing system was well received. More specifically, the responses to item #5 of the questionnaire suggest that this group found the computer quizzing system "helpful," while the responses to item #6 suggest that the CMI group found taking quizzes at a computer terminal to be "pleasant."

Finally, responses to item #2 of the questionnaire indicate that the CMI group gave the course a higher "over-all" rating than did the Traditional group.

In addition to suggesting that CMI leads to significant differences over traditional approaches in both the amount learned and the students' ratings of various aspects of the class experience, the data further indicate that CMI offers an alternative to the use of student proctors in individualizing the learning process.

PSI: Are Proctors Really Necessary?

The difference of 16.4 percent between the CMI and Traditional groups on their final exam performance compares quite favorably with differences reported between other traditionally taught introductory psychology courses and Keller's PSI technique. Such differences have been replicated using a wide variety of texts and course materials (for excellent summaries of the relevant PSI literature see Robin, 1974; Ryan, 1974, and Sherman, 1974).

The fact that this 16.4 percent difference was achieved without the use of proctors tentatively suggests that the effectiveness of PSI may not be due to the use of proctors, per se, but to some other aspect of the course (e.g., the use of objectives, mastery criteria, etc.). Although the present data do not permit precise determination of the effective element(s) of PSI, they do suggest that the functions which proctors perform can be carried out more reliably by a computer. This possibility should be of interest to instructors experiencing difficulties in obtaining, training, and/or compensating human proctors.

In addition to greater reliability in the quality of feedback provided to the student, CMI can also provide automatic test item analysis for each item which, when accumulated over a long period of time, increases the likelihood that an instructor will be able to make more valid decisions about which test items, answers, and/or objectives need modifying. Such a procedure is certainly less

haphazard than the practice, found in typical PSI courses, of asking proctors to verbally report "troublesome" items to the instructor.

Future Directions

Plans for the near future include the development of a test generating program that is compatible with our current software. Once this program is complete, any faculty member who creates an extensive set of test items could generate an almost infinite variety of test and quiz forms for classroom use as well as on-line quizzing. At the same time, a program will be developed to interface a mark sense scoring device with the present software, so that an instructor using paper and pencil tests can take advantage of the record keeping and test item analysis capabilities which exist in the system. The utilization of this test scoring program would enable an instructor to pool test item analysis data from both on-line quizzing and off-line testing, thereby increasing the data base for item analyses.

Notes

1. The software described here was written in time-shared BASIC for a Hewlett Packard 2000E by J. Roll and J. Siedband of Harper College. The authors gratefully acknowledge the help of J. Siedband whose early input and continued consultations made possible the development of these programs.

2. Originally there were ten versions of this program, one for each unit quiz. With our current Hewlett Packard 2000 Access System there is only one program and, depending on which unit the student is being quizzed, different files are automatically assigned to it.

3. A copy of the original forty item questionnaire as well as the students' responses can be obtained from the authors.

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Appendix

```
RUN
PSYTST

TEACHER'S NAME?ROLL
YOUR NAME?GORT

YOU SHOULD BE READY FOR A QUIZ ON CHAPT 1 & APP
DO YOU WANT TO TAKE THE QUIZ NOW (YES/NO)?Y

ANSWER ALL QUESTIONS BY TYPING YOUR ANSWER
IMMEDIATELY AFTER THE QUESTION MARK.

QUESTION # 1
TO GENERALIZE A RELATIONSHIP STATEMENT TO EVENTS OTHER THAN THOSE SPECIFICALLY
OBSERVED. IT IS MOST IMPORTANT TO A) SELECT REPRESENTATIVE SAMPLES B) VARY DEPENDENT
VARIABLES C) USE A DOUBLE BLIND CONTROL

ANSWER?A

QUESTION #2
A MAJOR ADVANTAGE OF NATURALISTIC OBSERVATION OVER THE EXPERIMENTAL METHOD IS
THAT IN THE FORMER, ENVIRONMENTAL EVENTS CAN BE MORE EASILY MANIPULATED.
A) TRUE    B) FALSE

ANSWER?A

QUESTION #3
AN OLD TELEVISION COMMERCIAL INSISTED THAT 'ATHLETES ARE MADE, NOT BORN.' THE
MANUFACTURER WAS OBVIOUSLY TRYING TO CONVINCE PEOPLE THAT ATHLETIC ABILITY WAS A
FUNCTION OF AN ORGANISM'S A) NATURE   B) NURTURE

ANSWER?B

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

QUESTION #10
WHICH OF THE FOLLOWING IS NOT AN EXAMPLE OF BEHAVIOR? A) WALKING B) FIXING A CAR C)
THINKING ABOUT DINNER D) WRITING A POEM

ANSWER?C


DO YOU WISH TO DOUBLE CHECK ANY QUESTIONS (YES/NO)?Y
WHICH ITEM NUMBER?2


QUESTION #2
A MAJOR ADVANTAGE OF NATURALISTIC OBSERVATION OVER THE EXPERIMENTAL METHOD IS
THAT IN THE FORMER, ENVIRONMENTAL EVENTS CAN BE MORE EASILY MANIPULATED. A) TRUE B)
FALSE

YOUR FIRST ANSWER WAS: A
WHICH ANSWER DO YOU CHOOSE NOW  B


DO YOU WISH TO DOUBLE CHECK ANY QUESTIONS (YES/NO)?N

 9          CORRECT OUT OF      10

GREAT! YOU ONLY MISSED ONE. GO TO THE NEXT UNIT.
```

```
GET-RESPON
RUN
RESPON

THIS PROGRAM DOES ANY OF THE FOLLOWING:
      1)MAKES A PRINT-OUT OF THE QUIZ RESPONSES OF THE STUDENT SPECIFIED BY THE
        PROGRAM USER.
      2)MAKES A PRINT-OUT OF THE QUIZ RESPONSES OF EVERY STUDENT IN THE FILE.
      3)ERASES THE QUIZ RESPONSES OF ALL THE STUDENTS IN THE FILE.
WHICH OPTION# DO YOU CHOOSE? 1

STUDENT'S NAME?GORT

GORT                                                        JAN 10    1977

                                QUIZ 1A

    ITEM #        REC.#      YOUR ANS.        SCORE      RESP. TIME (SECONDS)

      1            15            A              1              12
      2            30            A              0               6
      3             1            B              1               6
      4            42            SCATTER        1              13
      5            44            HIGH           1              14
      6            18            B              1              32
      7            36            DESCRIPTIVE    1              20
      8            45            B              1              40
      9            20            DEPENDENT      0              12
     10             4            C              1              29

ITEMS REVIEWED

      2            30            B              1               4

 9       OUT OF 10        CORRECT
ELAPSED TIME =5       MINUTES

YOU MISSED ITEM #9              REC # 20

YOU WERE NOT ABLE TO RECOGNIZE AN EXAMPLE OF AN INDEPENDENT VARIABLE  SEE PAGE 533
OF THE TEXT.

STUDENT'S NAME?
STOP

RSLTS
                                DEC 22, 1976

4) DORIS BERO
CH 10          10                                        10 OCT 13
CH 11           9                                        10 OCT 21
CH 2            9                                        10 OCT 28
CH 3            7              10                        10 NOV  9
CH 4           10                                        11 NOV  9
CH 8            9                                         9 NOV 23
CH 9            8              9                         10 NOV 23
CH 13&14        7              9                         10 DEC  2
                                        TOTAL=70
                                70 OUT OF 70 POINTS= A
```

5) LYNN BICKNASE

CH 10	10		10 OCT 13
CH 11	4	8	8 OCT 21
CH 2	7	8	8 NOV 2
CH 3	5	8	8 NOV 15
CH 3	7		7 NOV 18
CH 8	8		8 DEC 2
CH 9	6	10	10 DEC 7
CH 13&14	10		10 DEC 9

TOTAL=59
59 OUT OF 70 POINTS= B

QUIZ #	TOTAL # OF TRIALS	MEAN # OF TRIALS	S.D.
Ch 1&APP	4	2.00	1.00
CH 6	4	2.00	1.00
CH 10	34	1.00	0.00
CH 11	59	1.90	0.73
CH 2	48	1.60	0.66
CH 3	47	1.62	0.72
CH 4	43	1.48	0.62
CH 8	52	1.79	0.85
CH 9	56	1.93	0.78
CH 13&14	46	1.64	0.77
TOTALS	393	1.62	0.75

MEAN TOTAL POINTS= 64.64
STANDARD DEVATION= 5.41